Appendix A: No Net Rise/Compensatory Storage Standard

1. It is estimated the that **hydrologic and hydraulic engineering costs** to develop in the flood fringe and meet the No Net Rise/Compensatory Storage standard will be similar to those that are incurred today for development or stream crossings within the floodway.

2. From discussions with engineering firms, the **costs to develop in the floodway** vary significantly, but typically **range between a few thousand dollars to fifteen thousand dollars**. The replacement of stream crossing structures in the county where the replacement is going to have more flow capacity are on the low end, while more complicated stream crossings and developments with fill in the floodway can be on the high end of the range.

3. **Typical work involved for engineering** is surveying of cross sections, review of existing hydraulic models, review of hydrologic conditions, and the hydraulic modeling for the proposed structure.

4. **Examples** include hydraulic **engineering costs** of approximately $12,000 for a recent ~60-acre development project and $24,000 for the Lincoln Ballpark project (~90 acres), or about $200/acre and $300/acre respectively.

5. The table below depicts the ***average estimated*** **range in costs** for development in this area based upon discussions with engineering firms, and the **potential increase in engineering costs** for development in the floodplain that could be expected **if a No Net Rise/Compensatory Storage standard were adopted**:

Total Development Costs	$35,000-$45,000/acre	100%
Existing Surveying/Engineering Costs	$3,500-$4,500/acre	10%
Existing Land Planning Fees	$1,750-2,250/acre	5%
Additional engineering costs anticipated to meet No Net Rise/Compensatory Storage standard	Mapped/Studied Areas: <u>Salt Creek Floodplain:</u> $3,000 + $200/acre <u>Other Floodplains:</u> $3,000 + $100/acre Unmapped/Unstudied Areas: <u>Salt Creek Floodplain:</u> $6,000 + $200/acre <u>Other Floodplains:</u> $6,000 + $100/acre	*Additional Costs:* 100-acre site: 0.3%-0.6% 50-acre site: 0.4% -0.7% 10-acre site: 0.9%-1.7%

Appendix B: Stream Crossing Structures

1. There are circumstances in which it is **structurally or financially infeasible to construct stream crossings without causing any rise** in flood heights in the flood fringe. For example, on wide creeks it may be necessary to place piers within the flowage area. The piers act as an obstruction, and depending on their number and width will cause an increase in the water surface elevation.

2. Conversations with floodplain managers from other communities and other research indicates that **adopting a No Net Rise/Compensatory Storage floodplain standard will increase the cost of constructing new stream crossing structures.** Based on anecdotal evidence, it appears this increased cost **may approximate 25%.** However, the increase could be more for major structures, and also could be reduced if the standard is coupled with the ability to use compensatory storage, property rights acquisition, and increases in downstream conveyance capacity.

3. In areas where a No Net Rise floodplain standard is associated with other constraints such as in King County, Washington the **increased cost can be even more substantial**. King County has additional standards that require bridges to have a 6-foot freeboard above the 100-year flood level and do not allow any piers below the 'ordinary high water mark.' These are significant limitations, and the increase in bridge design and construction cost is estimated to be 40% for those bridges where backwater is a constraint.

4. When considering how this standard would be applied in Lincoln, it may be **fiscally impractical to construct a crossing that will not cause a rise** in flood heights in locations where no previous crossing has been built. For example, a bridge constructed to span the Salt Creek *Floodway* south of Lincoln would be 1,300 feet in length, whereas to **span the entire Salt Creek *Floodplain*** south of Lincoln would require a bridge 2,500 feet in length, and the **cost would increase** accordingly.

5. In some cases, stream crossings and utilities may cause an increase in flood stages but will not necessarily impact a significant flood storage area. Thus, one practical **alternative may be to allow a rise if property rights or flowage easements are acquired** in the area where flood heights are

increased to offset the impacts of stream crossings. Compensatory storage would be required to offset any incidental loss in flood storage.

6. **Where existing stream crossing structures exist**, <u>and the grade of the road is not being raised,</u> a No Net Rise/Compensatory Storage standard **would not be anticipated to have a significant impact on bridge and culvert replacements**, since most replacements meet a higher standard than the older structures being replaced.

Appendix C: Best Management Practices

Preservation of stream buffers is a 'Best Management Practice' which is included as a separate item (Item 4) proposed as a standard for floodplains. Stream buffers provide water quality and stream stability benefits, as well as assist in reducing the velocity of flood waters, and can be designated as a particular width and composition. **For this reason, buffers may be the most appropriate BMP to include as a required standard** in floodplain areas. **Other BMP's** may be more difficult to quantify as a required standard for floodplain management and may be better implemented through a policy which **encourages and recommends their implementation**. Some relevant examples from Lincoln's Drainage Criteria Manual are listed below:

1. Extended Dry Detention Basins: require an area of 0.5 to 2.0% of drained area, no significant permanent water storage, approximately 40 hour drain time.
2. Retention (Wet) Ponds: Length to width ratio of 3:1 with inlet and outlet at maximum flow length, min depth 2 to 3 feet, maximum depth 9 to 10 feet, drainage area of 10 - 25 acres.
3. Constructed Wetlands: Require a perennial flow and near 0 slope, typically .1 acres in size draining 10 acres, length to width ratio of 2:1, 50 % should have depth of 6" or less, 25% from 6 - 12", and 25% from 2-3'.
4. Grassed Swales: Used to collect overland runoff from impervious surfaces, ground slopes not over 6%, runoff velocities of no more than 1.5 to 2.5 ft/s with a maximum design flow depth of 3 ft.
5. Sand Filters: Used at outlet of detention basins and to treat parking lot runoff.
6. Check Dams: Where swales or other waterways need protection to reduce erosion.
7. Temporary Sediment Basins: Used below disturbed areas generally greater than 5 acres, usually used for less than 18 months unless designed as a permanent pond.
8. Infiltration Trenches: Use in drainage areas less than 15 acres, sandy and loamy soils, no less than 3 ft. between bottom of infiltration trench and top of ground water table.
9. Porous Pavement: Used in low traffic areas, walkways, and infrequently used parking areas, slopes of less than 5%, should not be constructed over fill.

Appendix D: 100-Year Storm Limits Along Smaller Tributaries

1. New subdivision proposals are required to show the '100-year storm' limits along smaller tributaries outside of the FEMA-mapped floodplain. **Currently, the City applies the stormwater standards in these areas**, which require that the lowest minimum opening of a structure along a drainageway or overland flow route be at or above the 100-year storm elevation.

2. **Regulating these areas per the floodplain ordinance would pose administrative difficulties** unless these areas are master-planned, because information is submitted to the City in a piecemeal fashion, development by development.

3. The floodplain regulations require that the lowest finished floor of any structure within the mapped floodplain, including the basement, be elevated (or floodproofed) to 1' above the 100-year flood elevation. However, **structures that are outside of the mapped floodplain boundary may not receive adequate protection**, even if they are immediately adjacent to the floodplain. Because they are outside of the area 'zoned' as a floodplain, they may have doors or windows that are lower than the flood elevation.

4. The **stormwater standards are appropriate in these areas** because the smaller tributaries have a greater ratio of 'edge' to 'floodprone area'. Structures along the edge are protected by insuring that the grading and elevation of the site keeps the minimum opening above the 100-year storm elevation. There are numerous smaller tributaries where structures might be protected to a lesser degree on the 'edge' if the floodplain standards are applied in lieu of the stormwater standards.